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Short Communication

PRELIMINARY STUDIES ON MICROBIAL BIOMASS AND THE MICROARTHROPOD COMMUNITY AS SOIL HEALTH AND QUALITY INDICATORS IN URBAN GRASSLANDS, RĪGA AS AN EXAMPLE

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Anthropogenic pollution is considered as a one of the main factors that affects soil in urban areas. In 2014, soil quality of grasslands in Rīga was determined. The aim of the study was to determine microbial biomass and describe microarthropod communities in soils of different grasslands in Rīga city and to assess their use as indicators of soil health and quality of the urban environment. Six sampling plots with different building characteristics, density of street and rail network and transport load, and potential impact of pollution were selected for studies. The substrate-induced respiration method was used for determination of soil microbial biomass. Soil invertebrates were collected in sampling plots. Soil Mesostigmata mites, Oribatida and Collembola were extracted from samples and counted. In total over 9300 soil microarthropod individuals were recorded, of them 4500 Collembola, 3400 Oribatida and 1400 Mesostigmata mites. Statistically significant differences in soil microbial biomass among sampling sites were observed. Soil microbial carbon content significantly increased in most of sampling plots from July to October. To obtain more precise results in the future some modifications and optimisation of the standard method based on indicators will be necessary.

Key words: *biodiversity, soil microbial carbon, invertebrates, Collembola, Acari.*

Grasslands occupy 20% of the Rīga area (Laiviņa, 2000). Anthropogenic pollution is considered as a one of the main factors that affects soil in urban areas. Human activities change soil physicochemical properties, which affects nutrient viability and alters soil microbial biomass and activity (Zhao *et al.,* 2012). Due to the importance of the microbial community in providing fertility through nutrient turnover, microbial biomass is considered to be a sensitive indicator of soil health and quality (Shrestha *et al.,* 2005; Kara and Bolat, 2008). Microorganisms are described as good indicators of heavy metal contamination in soils influenced by human activities (Giller *et al.,* 1998; Yuangen *et al.,* 2005).

The soil microarthropod community is a good indicator of soil quality, and indicators can be specific species of whole taxonomic groups, for example, springtails (Collembola), epigeic beetles (Coleoptera) and various mites (Acari) (Gardi *et al.,* 2002).

The aim of the study was to determine microbial biomass and microarthropod communities in soils of different urban grasslands in Rīga and to assess their use as indicators of soil health and quality of the urban environment.

Six sampling plots were selected for the study of grassland soil quality in Rīga. The selected grasslands in surrounding building characteristics, density of street and railway network and transport load, the potential impact of pollution, as well as other characteristics of the urban environment. Bolderāja (sampling plot No. 1), Voleri (2) and Sarkandaugava (5) sampling plots were located very close to the Rīga harbour complex and individual factories. Imanta (3), Šķirotava (6) and also Sarkandaugava (5) sampling plots were located within intensive multi-storey (5 storeys) residential areas developed in the 1960s–1970s. The Central sampling plot (4) was located in an area of administrative buildings, art and entertainment objects (Fig. 1, Table 1). The sampling plot locations in street lawns or lawns in courtyards represented different land-use type and intensity of management: (Table 1). Lawn trampling degree in plots was determined by loss of vegetation cover and plant community structure. Trampling intensity was defined as high when dominant plants were those characteristic of intensively trampled places, for example, *Plantago major, Poa annua, Potentilla anserina, Polygonum arenastrum,* and *P. aviculare*. Soil samples for analysis of microbial biomass were collected in July and October 2014. Sampling proce-

Table 1

DESCRIPTION OF RESEARCH SAMPLING PLOTS AND CHARACTERISTICS OF SOIL SAMPLING AREA

District	Nearest street	Geographic coordinates		Plot code on map	Distance from road, m	Origin and management# of grasslands	Soil type	pH (July)	Soil trampling rate
		X	Y						
Bolderāja	Flotes Str.	501250	6322903	1a	1	square, lawn*	Arenosole	6.76-7.38	low
	Piestātnes Str.	502494	6321247	1b	10	ruderal grassland*	Arenosole	7.02-7.04	low
Voleri	Voleru Str.	505295	6317739	2a	1	ruderal grassland*	Gleysole	7.38-7.39	low
	Voleru Str.	505300	6317740	2b	5	ruderal grassland*	Gleysole	7.17-7.22	low
Imanta	Kurzemes Avenue	501113	6313722	3a	1	ruderal grassland*	Arenosole	4.78-5.14	medium
	Kurzemes Avenue	501328	6313705	3b	5	ruderal grassland*	Arenosole	7.10-7.12	low
	Kurzemes Avenue	501206	6313691	3c	100	courtyard, lawn*	Arenosole	6.74-6.66	high
Center	K.Valdemāra Str.	506582	6312298	4a	5	square, lawn**	Technosole	6.64-6.83	medium
	Z. Meierovica Blvd.	506622	6312063	4b	10	lawn*	Technosole	5.42-7.00	high
Sarkandaugava	Viestura Avenue	507705	6318117	5c	80	courtyard, lawn*	Technosole	6.39-6.48	high
Šķirotava	Lokomotīves Str.	512628	6306936	6a	1	lawn*	Technosole	6.70-6.78	high
	Lokomotīves Str.	512620	6306929	6b	5	lawn*	Technosole	6.23-6.54	high
	Lokomotīves Str.	512593	6306961	6c	30	courtyard, lawn*	Technosole	5.49-5.50	medium

Management of grasslands: * extensive; ** intensive

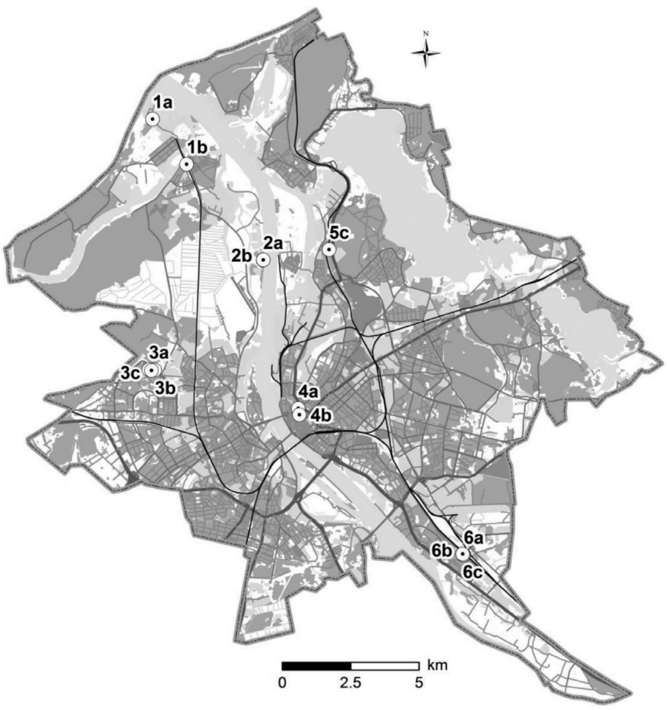

Fig. 1. Sampling plots and site location in Rīga (see explanation of numbers and letters in Table 1).

dure, transportation and storage were done according to ISO 10381-6 (2009). Four soil subsamples from one sampling site at each of several distances from a road were taken to a 0–10 cm depth. Subsamples were mixed and analysed as one sample. Soil moisture content was determined according to ISO 11465 (1993), and pH according to ISO 10390 (2005). The substrate-induced respiration method (ISO 14240-1, 1997) was used for determination of soil microbial biomass or soil microbial carbon (SMC). Evolved CO_2 was determined by capturing CO_2 into 0.1 N KOH and then measured by titration with HCl (Fluka Analytical, Germany) to a phenolphthalein end point. Soil respiration rate, in ml per kilogram per hour, was calculated according to Anderson and Domsch (1978), and SMC content was calculated according to ISO 14240-1 (1997).

At each sampling plot, about 1–1.5 l of soil was taken for investigations of soil microartropods. Samples were placed in plastic bags and brought to the laboratory. Soil samples were processed on a modified Tullgren funnels for 14 days. Soil microarthropods were extracted in ethanol and glycerol solution and afterward mounted on permanent slides in Fora-Berlese medium. Other soil invertebrates (Coleoptera, Diplopoda etc.) were left in ethanol.

Statistical analyses were performed using software R 2.14.1. To determine significant differences between each sampling site SMC data were submitted to one-way ANOVA, followed by Tukey's honest significant difference test ($p < 0.05$). Relationships between SMC and soil properties were analysed with correlation analysis.

The determined SMC content in soil samples collected in July was in the range of 0.375 $mg \cdot kg^{-1}$ to 0.385 $mg \cdot kg^{-1}$. In soil samples collected in October, we found an increase of SMC content in the most sampling plots to a range of 0.379 $mg \cdot kg^{-1}$ to 0.385 $mg \cdot kg^{-1}$ (Fig. 2). SMC content significantly increased in sampling plots Bolderāja (1b), Imanta (3b, 3c), Centre (4a), Sarkandaugava (5c) and Šķirotava (6b), while SMC content significantly decreased from July to October in sampling plot Centre (4b) (Fig. 2).

Significant differences in soil microbial biomass among sampling sites were observed in both seasons (Fig. 3A; 3B). At distance 1 m from a road, SMC was significantly lower in sampling plots Imanta (3a) and Center (4a) (Fig. 3A; 3B) in both seasons, in these plots there was medium soil trampling. The lowest SMC was in sampling plot Centre (4a), which was characterised by a high intensity of management. SMC content in soil samples collected at distance 5–10 m from a road were significantly lower in sampling plots Bolderāja (1b), a ruderal grasslands with low intensity of

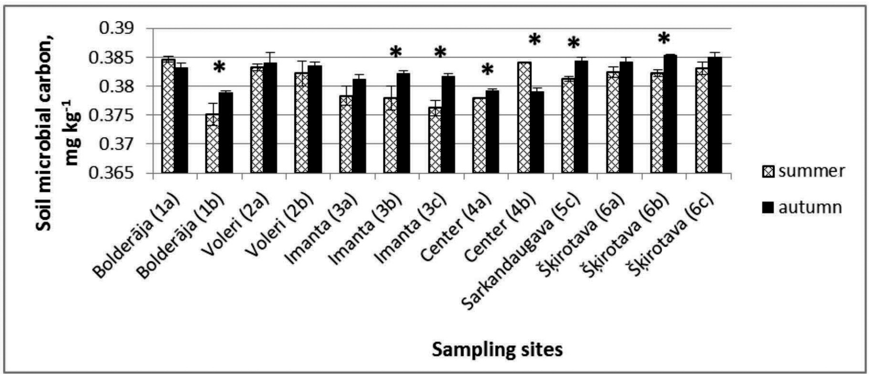

Fig. 2. Soil microbial carbon (SMC) content in soil samples from different urban grasslands collected in summer (July) and autumn (October). Data shown are mean values of three replicates with standard deviation. * indicates significant differences between SMC values, according to T test ($p < 0.05$), in each sample plot obtained in July and October.

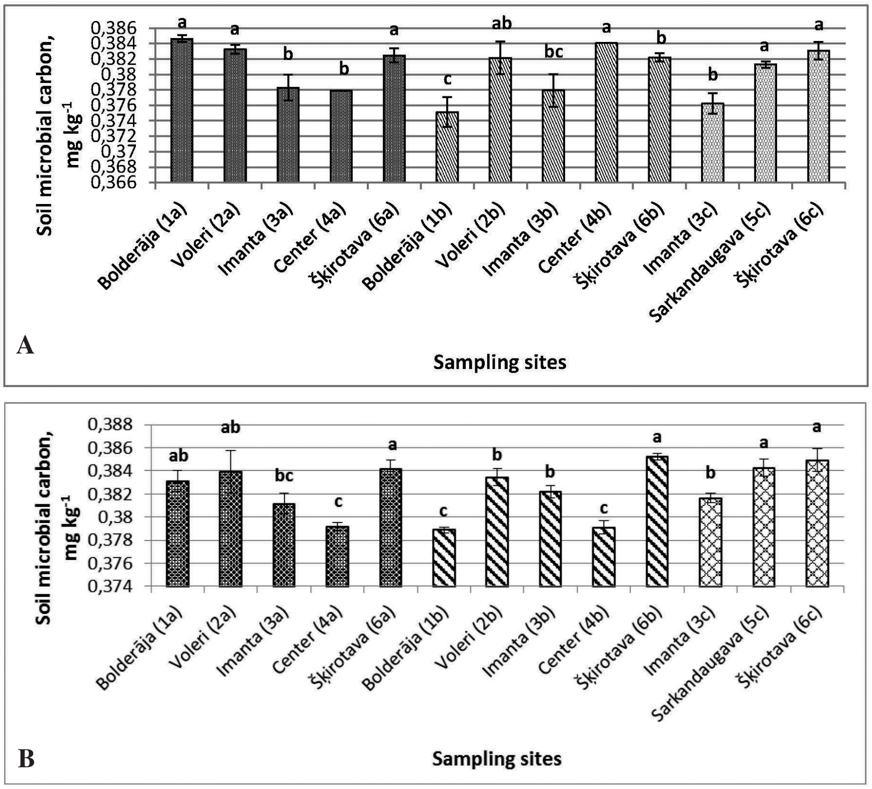

Fig. 3. Soil microbial carbon (SMC) content in soil samples, collected in different distances from road (a – distance 1 m (except sampling plot Center); b – distance 5–10 m; c – in courtyard). Samples collected in summer (A), autumn (B). Data shown are mean values of three replicates with standard deviation. Bars with different letters within samples collected at one distance from road (1 m or 5–10 m) and in courtyards indicates significant difference according to Tukey's honest significant difference (HSD) test ($p < 0.05$).

management, and Centre (4b), a lawn with low intensity of management. SMC content in Imanta (3c), a courtyard site with rich soil and relatively high trampling effect, significantly differed from courtyard samples Sarkandaugava (5c) and Šķirotava (6c).

Soil invertebrates were collected at the respective sampling plots in October 2014. In total over 9300 soil invertebrates were recorded, of them 4500 Collembola, 3400 Oribatida and 1400 Mesostigmata mites. The highest total number of invertebrates was found in Bolderāja (1a), a lawn with rich soil, litter, vegetation and low trampling degree (Table 1; Fig. 4). This plot also had the highest number of Oribatida mites. Mesostigmata mites, Collembola and the other mites were most numerous in Imanta (3c), a lawn with rich soil, vegetation and relatively high trampling effect (Table 1). The remaining invertebrates were not counted. The preliminary study seems to indicate that the main factors affecting soil invertebrates are related to habitat. Soil invertebrates closely interact with abiotic environmental factors, which affects their activity. As many species respond proportionally even to minute changes in the environment conditions, they can be used as indicators of soil quality (Reddy, 1986; Coleman, 2008). In the future, specimens of the most numerous groups will be determined to the species level to determine specific species or groups of species that should be studied in future work to evaluate human impact on soil fauna.

Soil around roads is highly influenced by human activities. Therefore, the physical and chemical properties of analysed soil differs not only among sampling plots, but also within sampling plots. Correlation among SMC content in soil and soil type was not observed. Soil properties like pH and water content can significantly affect soil respiration rate (Lin and Brookes, 1999) and determination of soil microbial carbon. Soil pH in collected samples varied from 4.78 to 7.48 (Table 1). According to Cheng and Coleman (1989), if soil pH is 6.5 then SIR (substrate induced respiration) measurements can be associated with high experimental errors, as not all respired microbial CO_2 will be trapped in added alkaline flasks, due to part of the CO_2 being dissolved and

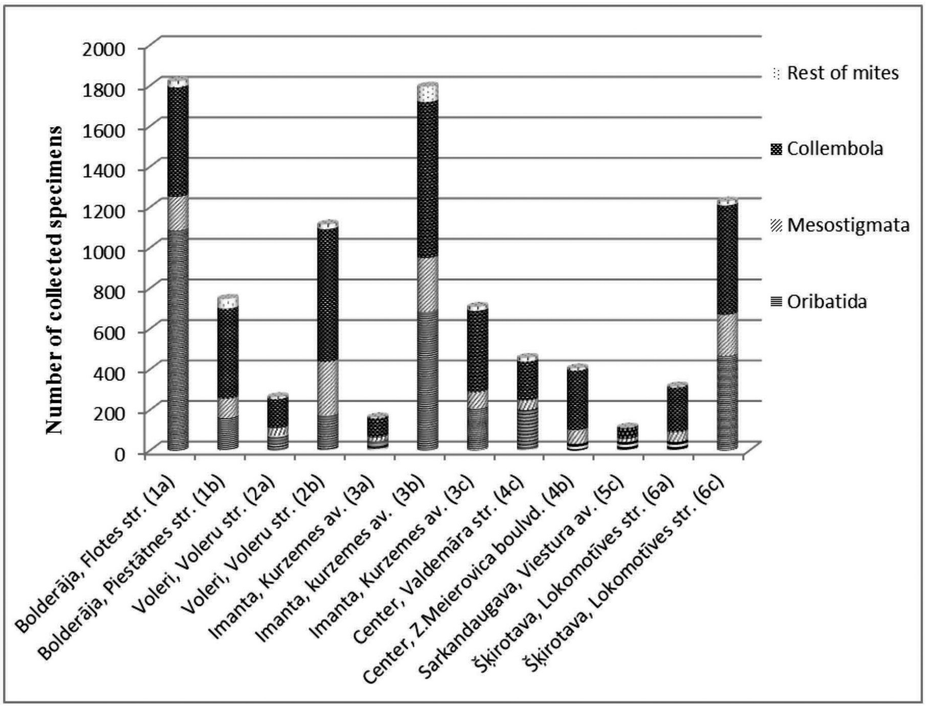

Fig 4. Comparison of number of sampled soil microarthropods by taxanomical groups in sampling plots in urban grasslands.

trapped in soil alkaline solution. As more than half of our tested soil samples had pH greater than 6.5, in the future optimization of the method will be necessary. Lin and Brookes (1999) indicated that water content in soils has an important role in SIR analysis. Determined water content in analysed soil samples was from 9% to 35.9%. Despite of great variation of pH and water content among sampling sites, there was no statistically significant correlation ($p > 0.05$) between soil microbial carbon and pH or water content.

Although SIR technique is simple and rapid method for determination of microbial biomass in the soil and for evaluation of soil function, difficulties arise in its use for analysis of soil of urban grasslands due to high variation of soil parameters. Therefore modifications and optimisation of the standard method employed will be necessary. In the next step, we will analyse changes of SMC content and microartropods in relation to distance from roads, and test for relationships between soil microbial biomass and grassland vegetation, soil mineral and heavy metal content, the intensity of traffic and air pollution loads.

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SĀKOTNĒJIE PĒTĪJUMI PAR AUGSNES MIKROBIĀLO BIOMASU UN AUGSNES SĪKPOSMKĀJU SABIEDRĪBĀM KĀ AUGSNES VESELĪBAS UN KVALITĀTES INDIKATORIEM RĪGAS PILSĒTAS URBĀNAJOS ZĀLĀJOS

Antropogēnais piesārņojums tiek uzskatīts par vienu no galvenajiem faktoriem, kas ietekmē augsni pilsētās. 2014. gadā uzsākts pētījums par augsnes kvalitāti urbānajos zālājos Rīgā. Pētījuma mērķis bija noteikt augsnes mikrobiālo biomasu un augsnes sīkposmkāju kopienu dažādu zālāju augsnēs Rīgā un izvērtēt iespējas tos izmantot kā pilsētvides augsnes veselības un kvalitātes rādītājus. Rīgā atšķirīgos pilsētas rajonos tika izvēlēti seši dažāda lieluma parauglaukumi ar atšķirīgām vietas apbūves īpatnībām, ielu un dzelzceļu tīkla blīvumu un transporta noslogojumu, vidi piesārņojošo objektu iespējamo ietekmi, kā arī citām, urbānu vidi raksturojošām īpatnībām. Substrāta izraisītas elpošanas metode izmantota, lai noteiktu augsnes mikrobiālo biomasu. Atsevišķos parauglaukumos tika ievākti un uzskaitīti augsnes sīkposmkāji — Mesostigmata ērces, Oribatida un Collembola. Kopā parauglaukumos ievākti vairāk kā 9300 augsnes sīkposmkāji, no tiem 4500 Collembola, 3400 Oribatida un 1400 Mesostigmata ērces. Konstatētas statistiski nozīmīgas augsnes mikrobiālas biomasas atšķirības starp parauglaukumiem. Vairumā parauglaukumu (izņemot stipri ietekmētu parauglaukumu Z. Meirovica bulvārī) laikā no jūlija līdz oktobrim augsnes mikrobiālā oglekļa saturs būtiski palielinās. Lai iegūtu precīzākus rezultātus, nākotnē nepieciešama augsnes mikrobiālās biomasas noteikšanas metodes optimizācija.